DESIGN OF REVETEC ENGINE CAM WITH CYCLOIDAL MOTION PROFILE

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ABSTRACT

Efficiency of conventional engines reduced due to heat and friction losses. Some of the input energy is lost in exhaust gases and water cooling and the mechanical losses due to friction. All conventional engines are using crankshafts to convert the piston reciprocating motion to a rotating motion in the drive line, but crankshafts are responsible of side thrust force, vibrations and also they are not efficient in transferring the power to the drive line. Crank-less and free piston engines were a good example to overcome the crank shaft problems, but these new kinds of engines are facing a control and starting problems. Revetec engine is a new engine arrangement used to increase engine's efficiency by replacing the crankshaft and the connecting rod used in conventional engines by cams to control the piston movement. In revetec engine, it consists of two counter rotating three-lobed cams gearing together. So, both cams contribute of forward motion. Two bearings moving along the profile of both cams (four bearings for all) and stay in contact with the cams at all times. The two cams rotate and raise the piston with a scissor-like action to the bearings. It meaning, in every cycles of the revetec engine there are three power stokes compared to one power stroke in the conventional engines. Based on revetec engine performing, Cam profile contributes great effect in combustion characteristics, so it is very important to find the suitable cam profile to achieve the maximum cylinder pressure. In this project a computational work. Based on comparison result of the project between conventional engine and revetec engine. The result obtained from this study has shown that by using a cam profile, with which Cycloidal motion was applied to the piston, the cylinder pressure can be increased up to 23.91 percent.

ABSTRAK

Kecekapan enjin konvensional berkurangan kerana kehilangan haba dan geseran. Sebahagian daripada tenaga yang hilang dalam gas ekzos dan penyejukan air dan kerugian mekanikal yang disebabkan oleh geseran. Semua enjin konvensional menggunakan aci engkol untuk menukar pergerakan omboh salingan kepada gerakan berputar di talian drive, tetapi aci engkol bertanggungjawab memberi daya teras sampingan, getaran dan juga mereka tidak cekap dalam memindahkan kuasa kepada garis pemacu. Enjin omboh engkol-kurang dan bebas adalah satu contoh yang baik untuk mengatasi masalah aci engkol, tetapi jenis enjin baru ini menghadapi kawalan dan masalah sewaktu bermula. Enjin revetec adalah susunan enjin baru yang digunakan untuk meningkatkan kecekapan enjin dengan menggantikan aci engkol dan rod penyambung yang digunakan dalam enjin konvensional oleh sesondol untuk mengawal pergerakan omboh. Dalam enjin revetec, ia terdiri daripada dua sesondol kaunter tiga lobed berputar penggearan bersama. Jadi, kedua-dua sesondol menyumbang gerakan ke hadapan. Dua galas bergerak di sepanjang profil kedua-dua sesondol (empat galas untuk semua) dan tinggal di bersentuhan dengan sesondol pada setiap masa. Dua sesondol berputar dan meningkatkan omboh dengan tindakan gunting seperti galas. Ia makna, dalam setiap kitaran enjin revetec ini terdapat tiga kuasa stoke berbanding dengan satu kuasa lejang dalam enjin konvensional. Berdasarkan enjin revetec, profil cam menyumbang kesan yang besar dalam ciri-ciri pembakaran, jadi ia amat penting untuk mencari 'cam profile' yang sesuai untuk mencapai tekanan silinder maksimum. Berdasarkan hasil perbandingan projek antara enjin konvensional dan enjin revetec. Dalam projek ini kerja pengiraan. Keputusan yang diperolehi daripada kajian ini menunjukkan bahawa dengan menggunakan cam profile, dengan mana gerakan Cycloidal telah meningkatkan tekanan silinder kepada lebih 23.91 peratus.

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

LIST OF SYMBOLS

A	Piston Cross-Section Area
V	Cylinder volume
V_{Π}	Maximum volume
V_{O}	Minimum volume
P	Pressure
P	Cylinder Pressure
Q	Heat Addition
$\boldsymbol{\gamma}$	Specific Heat Ratio
x	Fraction Of Heat Released
ΘS	Start Of Heat Release
ΘB	The Time Scale For Heat Release
n	Value Used To Fit Experimental Data
s	Piston Stroke, M
r	Compression Ratio
X	Piston Displacement ,M

LIST OF ABBREVIATIONS

BDC	Bottom Dead Center
TDC	Top Dead Center
BTDC	Bottom Top Dead Center
TBDC	Top Bottom Dead Center
FYP	Final Year Project
W1	Week 1
CCE	Controlled Combustion Engine
SAE	Society of Automotive Engineering
ASME	America Society of Mechanical Engineering
ATDC	Acceleration Top Dead Center

CHAPTER 1

INTRODUCTION

1.1 BACKGROUND

Revetec engine is a new engine arrangement, were cams are used instead of crankshaft to convert the reciprocating piston motion to rotating motion. Crankshafts are inefficient devices for efficiently transferring power from the pistons to the driveline, with losses that can approach 36%. At the top of the piston stroke, where gas pressure is highest, force transfer efficiency is at its lowest, though it rises as the piston descends. Peak efficiency happens about 40% through the piston stroke, and then drops at an exponential.

In addition, the piston does not travel a path that is strictly parallel to the bore, so an angular force equal to the pressure on the top of the piston is transferred to the cylinder wall. This increases friction, wear, and fuel consumption. So, revetec engine is solution for this problem. By replacing the crankshaft and the connecting rod that used in conventional engines, the engine efficiency will increase by controlled combustion engine of the piston movement.

1.2 PROBLEM STATEMENT

Crankshafts are the main cause for many problems in the internal combustion engine, like vibration, noise and cylinder wear. These poor efficiencies of the crankshafts have leaded the engineers to invent other alternative to replace the crankshafts functions (Mikalsen, 2007). When using cams instead of crankshafts, the cam profile makes a great effect in combustion characteristics, so it is very important to find the suitable cam profile to achieve the maximum cylinder pressure. In this project, a comparison for one type of cam profiles, which gives a specific motion for the piston, mainly Cycloidal motion**,** to calculate the cylinder pressure during compression and combustion strokes. In this project an investigation of cam with cycloidal motion profile will be done to find the effect of the cam profile on the cylinder pressure. Revetec engine is a new custom engine.

1.3 OBJECTIVE

To investigate the effect of cam profile on the cylinder pressure

1.4 SCOPES

In this final year project there are three main point for the scope.

i. Modelling the cam profile using MATLAB.
ii. Simulating of cylinder pressure during the compression and exhaust strokes.
iii. Comparing these results with conventional engines.

1.5 FLOW CHART OF THE FINAL YEAR PROJECT

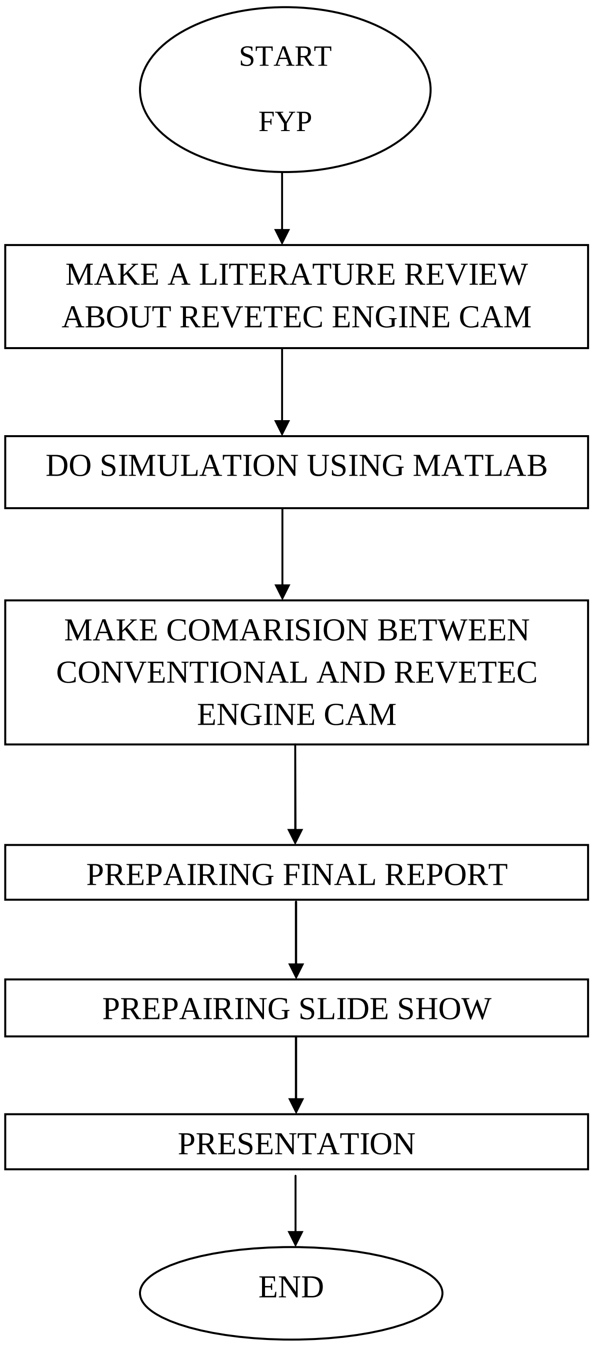

Figure 1.1: Flow chart of final year project

1.6 GANTT CHART

PROJECT ACTIVITIES	W1	W2	W3	W4	W5	W6	W7	W8	W9	W10	W11	W12	W13	W14
STUDY ABOUT REVETEC ENGINE CAM														
MAKE A LITERETURE REVIEW														
DO SIMULATION USING MATLAB														
MAKE COMPARISION BETWEEN CONVENTIONAL AND REVETEC ENGINE														
PREPAIRING FINAL REPORT														
PREPAIRING SLIDE SHOW														
PRESENTATION														

CHAPTER 2

LITERATURE REVIEW

2.1 INTRODUCTION

Currently, majority of the vehicle on the road used conventional engine. Revetec engine technology is still new in the automotive industry. Many people do not know the advantages of using revetec engine, when compared with conventional engines. It occurs due to lack of information on revetec engine. Therefore, research on revetec engine must be published to be seen by the public. So, people are more interested in studying or using technology of revetec engine.

With this study, the rate of wastage of fuel consumption can be reduced. This is because the revetec engine efficiency is better when compared with conventional engines. The main problem in the internal combustion engine to a conventional engine is the crankshaft. When the engine is running, a problem that often occurs like vibration, friction wears of the cylinder, and noise. Lack of efficiency of the engine requires the engineer to cope with a redesigned internal engine parts that can overcome the problem.

In 1996, Bradley Howell Smith, an Australian engineer conducting research and in 2006 he created a new display engine called Controlled Combustion Engine (CCE). This engine mechanism convert the reciprocating motion of the internal combustion engines pistons, to rotating motion in the drive line, by using two counter three-lobed cam geared together, two bearing run along the profile of both cam and stay in contact with the cam at all times known as Revetec engine (Bradley, 2006).

Revetec engine is a new engine design. Revetec engine, replace the crankshaft with the camshaft. In revetec engine, it consists of two counter rotating three-lobed cams gearing together. So, both cams contribute of forward motion. Two bearings moving along the profile of both cams (four bearings for all) and stay in contact with the cams at all times. The two cams rotate and raise the piston with a scissor-like action to the bearings.

It meaning, in every cycles of the revetec engine there are three power stokes compared to one power stroke in the conventional engines. In each stroke of the engine revetec, only 120 degrees cam rotates to complete a stroke, while the 360 degrees cam rotates required to complete a stroke by a conventional engine. That is why, cam profile contributes a major impact on engine performance and controlling the movement of the piston.

2.2 REVETEC ENGINE

The Revetec Engine design consists of two counter-rotating three lobed cams geared together, so both cams contribute to forward motion. Two bearings run along the profile of both cams with four bearings in all and stay in contact with the cams at all times. The bearings are mounted on the underside of the two inter-connected pistons, which maintain the desired bearing to three lobed clearances throughout the stroke. The two cams rotate and raise the piston with a scissor-like action to the bearings.

Once at the top of the stroke the air/fuel mixture is fired. The expanded gas then forces the bearings down the ramps of the cams spreading them apart ending the stroke. The effective cranking distance is determined by the length from the point of bearing contact to the centre of the output shaft. A conventional engine's turning distance is half of the piston stroke. The piston acceleration throughout the stroke is controlled by the cam grind which can be altered to suit a wide variety of fuels, torque requirements and rev range. The counter rotation is performed by a reverse gear set at a 1:3 ratio shaft providing two stroke piston to 360 degrees of output shaft rotation.

2.3 REVETEC ENGINE MODELLING

2.3.1 Revetec engine modelling for two stroke

With reference to Figure 2.1, there is shown two-stroke engine 1 comprising a single cylinder module having a single pair of cylinders made up of cylinders. Roller bearings are carried by shaft, which correspond to the roller bearings as generally indicated of figure 2.1

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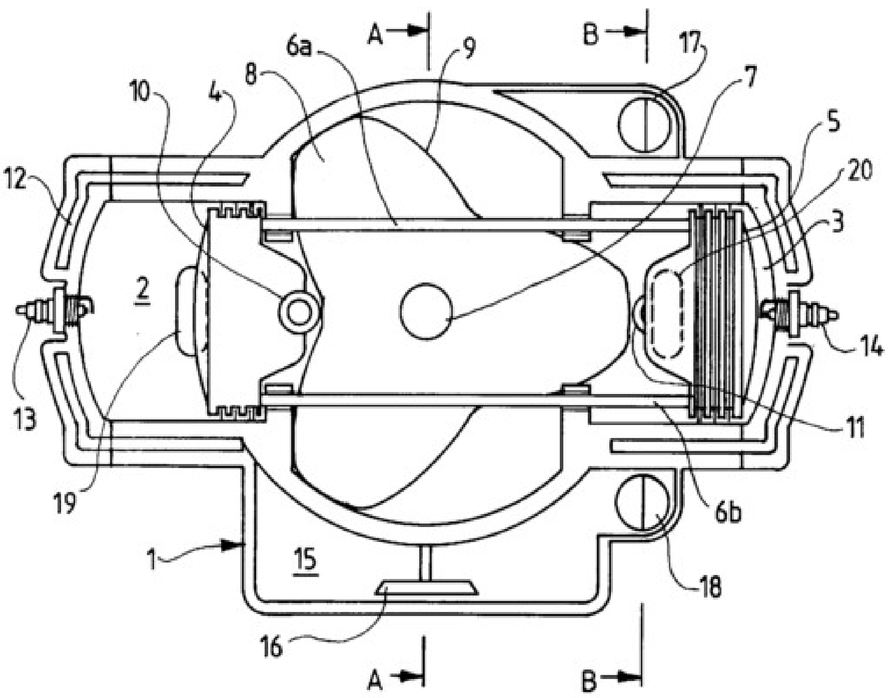

Figure 2.1: Cross-sectional view of a two-stroke engine comprising a single cylinder module with the cross-section being along the axis of the cylinders and transverse with respect to the engine shaft.

Source: Bradley (2006)

1- Comprising a single cylinder module, 2 and 3- cylinders. 4 and 5- pistons, 6a 6b- fours rod, 7- central shaft, 8 and 9- trilobate cams, 10 and 11- roller bearings, 12- water jacket, 13 and 14- spark plugs, 15- oil sump, 16- oil pump pickup, 17 and 18- balance shafts, 19 and 20- inlet ports of exhaust ports.

Turning to Figure 2.2, there is shown another two stroke engine having a single cylinder module. The engine is shown in partial cross-section. In effect, half of the engine block has been removed to reveal internal detail of the engine. The cross-section is in a plane coincident with the axis of the central shaft of the engine. The engine block has thus been split at its midline.

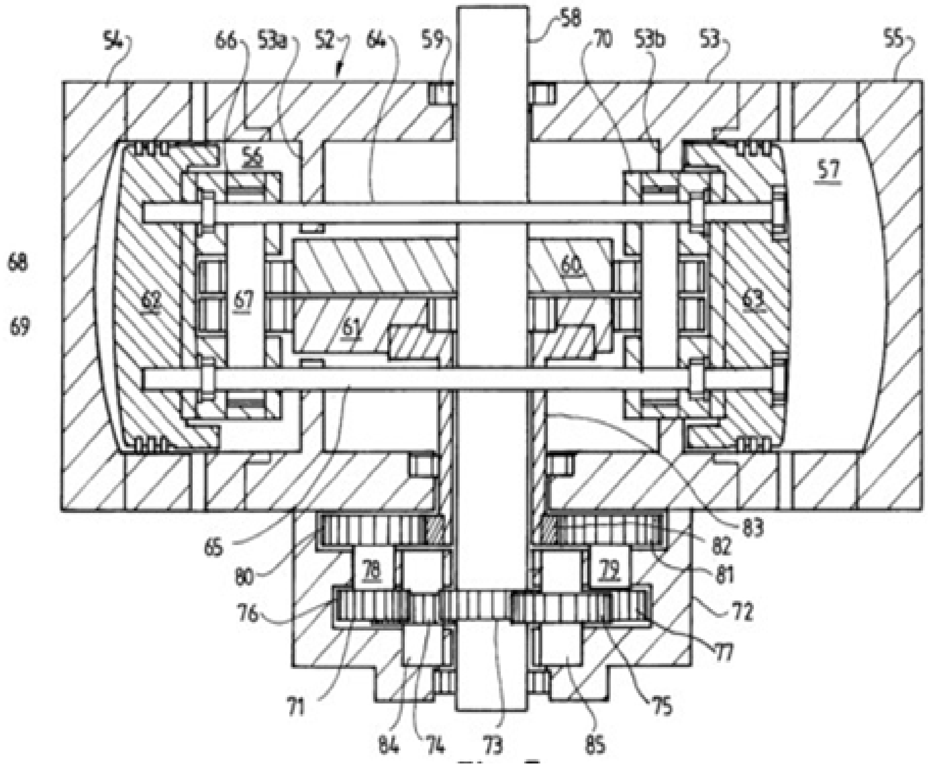

Figure 2.2: Cross-sectional view of another two-stroke engine comprising a single cylinder module with the cross-section being in the plane of the central shaft of the engine.

Source: Bradley (2006)

52- engine, 53- comprises block, 54 and 55- cylinder heads, 56 and 57- cylinders, 58- shaft, 59- roller bearings, 60- a first trilobate cam fixed, 61- counter rotating trilobate cam, 62- piston in cylinder 56, 63- piston in cylinder 57, 64 and 65- four connecting rods, 66- piston a bearing boss, 67- holds shaft, 68 and 69- roller bearings, 70- bearing boss, 71- gear train, 72- housing, 73- sun gear, 74 and 75- drive gears, 76 and 77- planetary gears, 78 and 79- shafts, 80 and 81- second set of planetary gears, 82- sun gear, 83-sleeve, 84 and 85- shafts.

An engine with offset cam contacting bearings is shown schematically in Figure 2.3. In this figure, which is a view along the central shaft of an engine, cam , counter rotating cam , and piston are shown. Piston includes bearing bosses and which carry roller bearings and, which bearings are shown in contact with a lobe, respectively, of the trilobate cams.

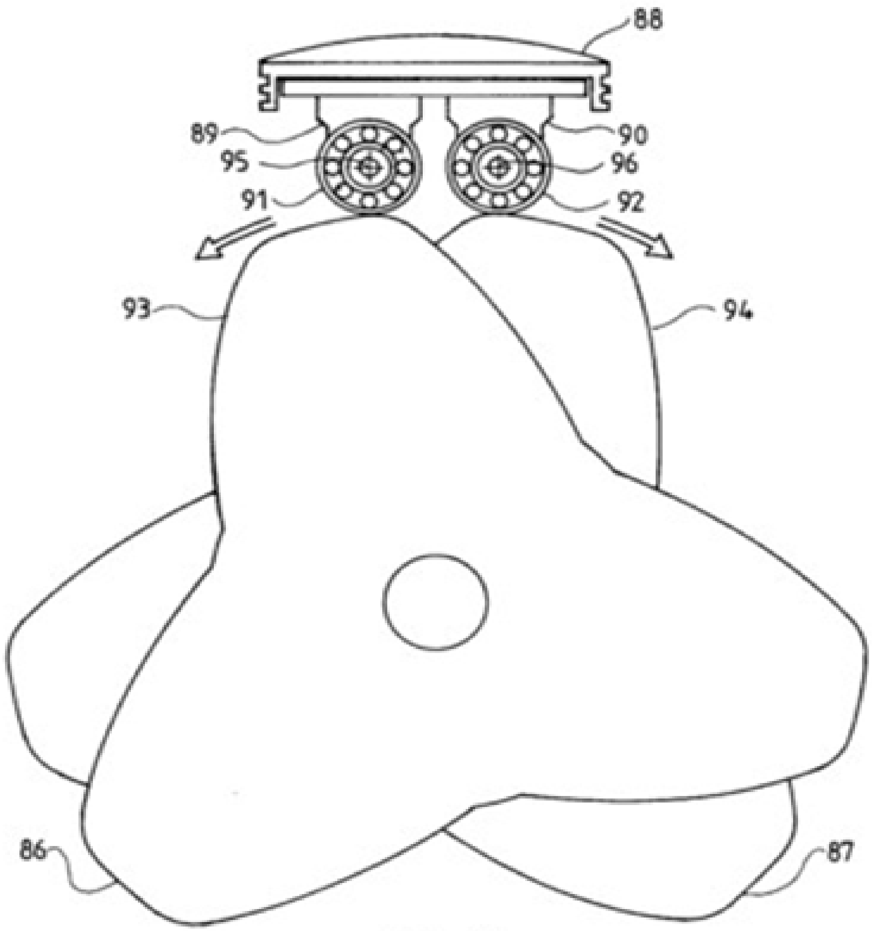

Figure 2.3: View of portion of an engine showing a piston in contact with counter rotating trilobate cams.

Source: Bradley (2006)

86- cam, 87- counter rotating cam, 88- piston, 89 and 90- bearing bosses, 91 and 92- roller bearings, 93 and 94- which bearings are shown in contact with a lobe, 95 and 96- axes

2.3.2 Type of revetec engine

Based on Figure 2.4, it shown one module can either comprise of two trilobate cams and either two, or four pistons in an “X” configuration.

Figure 2.4: Revetec engine for X-Series.

Source: Bradley (2006)

Refer to Figure 2.5 it show revetec engine for boxer series. In a boxer, the opposing pistons move away from each other and then towards each other. In this figure 2.5, they move in the same direction.

Figure 2.5: Revetec engine for Boxer- Series.

Source: Bradley (2006)

With reference to Figure 2.6, 120° might be described as the natural angle for a V type of engine cylinders fire every 120° of camshaft rotation. The 120° layout also produces an engine which is too wide for most automobile engine compartments like used in racing cars.

Figure 2.6: Revetec engine for 120DegV- Series.

Source: Bradley (2006)

With reference to Figure 2.7, the most efficient cylinder bank angle for a V type of is 60 degrees, minimizing size and vibration. While 60° V type of engines are not as well balanced as inline-6 and flat-6 engines.

Figure 2.7: Revetec engine for 60DegV- Series.

Source: Bradley (2006)

According to Figure 2.8, In general use it refers to any type of straight engine. Internal combustion engine with all cylinders aligned in one row, with no offset.

Figure 2.8: Revetec engine for Inline- Series.

Source: Bradley (2006)

2.3.3 Advantage and disadvantage

Advantage of controlled combustion engine (CCE)

i. Approximately one quarter the size and weight of a conventional engine combined with improved output substantially increases power/weight and torque/weight ratio.
ii. Fewer moving and total components. As a result of fewer components, more easily manufactured than conventional engines.
iii. Identical cylinder head assembly to conventional engines. Most existing head technology can be either adapted or utilised.
iv. Eliminated irregularly reciprocating components such as connecting rods.
v. Output shaft can be run in either direction if multi lobed cams with symmetrical lobes are employed.
vi. All rotational forces are counteracted via the counter rotating cam eliminates the need for a heavy flywheel.
vii. Torque and power output can be varied using a fixed capacity and piston stroke.

viii. The CCE can be designed to operate at greatly reduced operating speeds while delivering high torque output.
ix. Substantial reduction in stroke reduces heat loss through cylinder wall.
x. Extended piston dwell is possible because engine design allows a lower than normal compression ratio to be used reducing power loss from compression cycle.
xi. Maximum mechanical advantage can be applied to output shaft at only 10 degrees ATDC utilising high cylinder pressure early in the stroke, compared to around 60 degrees ATDC for conventional engines.
xii. Lower emissions can be achieved due to increased control over combustion.
xiii. Extremely low idle speed due to increase in mechanical efficiency at the top of the stroke.
xiv. Little or no bore contact/piston side thrust, which reduces wear on cylinder bore.
xv. Can have different port timing on compression stroke than power stroke allowing better control two-stroke.
xvi. Lower centre of gravity.
xvii. Due to controlled piston acceleration rates the CCE reduces engine vibration.

Disadvantage of controlled combustion engine (CCE)

i. Vibration: it occur when engine in overheating
ii. Emissions: at higher performance the release of HC is reduce, but higher of NOx is increase
iii. Overheating: for higher performance engine the ability to overheat is higher.

2.4 TYPE OF CAM

2.4.1 Definition of cam

Cam is defined as a machine element having a curved outline or a curved groove. By oscillation or rotation motion, it gives a predetermined specified motion to another element called the follower.